TOPOGRAPHIC AND BATHYMETRIC DATA INVENTORY:

Gulf of Mexico

Part I of *A Roadmap to a Seamless Topobathy Surface*

National Oceanic and Atmospheric Administration (NOAA)

NOAA Coastal Services Center
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

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TABLE OF CONTENTS

ABOUT THE SERIES: *A Roadmap to a Seamless Topobathy Surface*

A topobathy digital elevation model (DEM) is a single surface combining the land elevation with the seafloor surface—and which can be used to examine processes that occur across the coastal and nearshore areas. *A Roadmap to a Seamless Topobathy Surface* (*Roadmap*) is a series of documents and maps that seek to improve and streamline the process of creating a topobathy DEM. The series aims to make topographic and bathymetric data and reference information accessible and make connections between data set quality and DEM application (such as coastal inundation modeling). Understanding the links between input data quality and application can help users create a DEM surface designed for a particular purpose, can help data collectors provide data sets that meet needs, and can assist technical users in defining their data requirements more explicitly.

The *Roadmap* examines resources and processes associated with DEM creation, including the following: (1) available data resources, (2) processes to generate high-resolution DEMs that minimize error, and (3) examples of topobathy applications. The target audience for this suite of information includes technical users of surface data within coastal management groups, scientists, federal and state agencies, and local offices using topographic and bathymetric data for technical applications. The *Roadmap* may also be useful to managers who are involved in activities such as planning a data collection. This series of products will help detail the steps required to create seamless coastal maps—a task that has been highlighted as an important national need by the National Research Council.

The first part of the *Roadmap* series—this set of maps and information—is an inventory of available topographic and bathymetric data resources for the Gulf of Mexico: *Topographic and Bathymetric Data Inventory: Gulf of Mexico (Gulf Inventory)*. The Gulf of Mexico coastal area was chosen for this project to assist data coordination efforts and to enhance geospatial capacity across the Gulf states. The *Gulf Inventory* is meant to increase awareness and use of existing topographic and bathymetric data sets, decrease duplication of effort, and strategically target data collections to fill gaps. It is a "snapshot" of data availability as of November 15, 2007, and it identifies location, collection date, and sources of available data sets. This resource is currently available on the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center's website (*www.csc.noaa.gov/topobathy/*). The next *Topographic and Bathymetric Data Inventory* will be for the Southeast portion of the U.S., from Florida to Maryland.

Topographic and Bathymetric Data Considerations: Datums, Datum Conversion Techniques, and Data Integration (Data Considerations) is the second part of the *Roadmap*. It is important for a surface to have data inputs that are positioned in reference to the same metric if it is to be used to accurately portray the nearshore and coastal areas. This document strives to improve and streamline the process of creating DEMs by providing a review of available datum conversion and integration techniques. It describes the importance of establishing a uniform reference for multiple data sets and techniques for manipulating and joining data sets. This document provides information on vertical and horizontal references (datums) for data sets and addresses the need for and the importance of datum conversion. It also introduces available datum conversion techniques, details the resources necessary to use each technique, and discusses limitations and error for each technique. Once data sets have a uniform reference, many data integration

techniques are available to create a topobathy surface that suits the final DEM application, and many common data integration techniques are addressed in this document.

The third part of the *Roadmap* will highlight some common coastal applications that can benefit from a highly accurate, high-resolution DEM. This reference, which is not yet completed, will describe applications of topographic, bathymetric, and topobathy DEMs and address standards for input data and the resulting DEM for an application. This information will help guide users on the practical and potential need for, and uses of, coastal elevation data and also provide technical users of elevation data with information to create a DEM specific to the needs of their application. Some examples of applications that may be addressed are shoreline delineation, wetland mapping, and inundation modeling. This reference is now in development and will be available online.

ABOUT THE DATA INVENTORY: *Gulf of Mexico*

To understand the effects of a change in coastal water level or the impacts of inundation, a seamless surface that represents both the topography of the land and the bathymetry of the seafloor is necessary. Such a seamless topobathy surface can require high-resolution data and is an important factor when modeling processes (such as storm surge) that occur across the land-water interface. The need for accurate, seamless coastal elevation maps was highlighted in the recommendations of the National Research Council report on *National Needs for Coastal Mapping and Charting*, specifically with respect to the coastal management community.

Topographic and Bathymetric Data Inventory: Gulf of Mexico (Gulf Inventory), the first part of the *Roadmap* series, strives to improve and streamline the process of creating digital elevation models by providing information about the availability and quality of elevation data. The *Gulf Inventory* indicates the location of available topography and bathymetry resources and the date on which they were collected. The inventory is available as a set of two maps: *Topographic and Bathymetric Data Gap Analysis by Location (Location Map)* and *Topographic and Bathymetric Data Gap Analysis by Collection Date (Collection Date Map)*. These maps, located at *www.csc.noaa.gov/topobathy/*, portray elevation and depth data sets through an on-line index interface.

This *Gulf Inventory* is meant to assist creators and users of digital elevation models in finding the highest-quality data sets and to inform coastal managers who might be purchasing data in of a coastal area. In these instances, the *Gulf Inventory* can help make smart decisions to employ better data sets and can assist in purchasing data sets that can improve coastal elevation models.

INTRODUCTION

During the 2004 hurricane season, Hurricane Ivan, the strongest storm of the season, made landfall and impacted the Alabama coast and the panhandle of Florida. In the wake of this major event, the need was evident for enhanced geospatial resources and coordination in the region. Hurricanes Katrina and Rita reiterated this need in western portions of the Gulf. As a complement to existing coordination and data collection activities, the *Topographic and Bathymetric Data Inventory: Gulf of Mexico (Gulf Inventory)* is designed to increase awareness of existing data sets, centralize information about data sets, and analyze gaps in data. In addition, this resource is intended to reduce or eliminate duplication of effort for data collection and to target data collection in areas where gaps exist.

The study area for the *Gulf Inventory* is the coastal zone from the U.S.–Mexico border to Monroe County, Florida (excluding the Florida Keys). The extent of the study area typically includes data found one or two counties landward and bathymetry found in the nearshore area. The nearshore bathymetry and coastal topography are of primary interest to this investigation because of the wide range of applications that require a seamless surface that includes both the topography of the land and the bathymetry of the seafloor, a topobathy surface. A topobathy surface is necessary for representing processes that occur across the land–water interface, such as inundation from a storm or an extreme high tide. Because of the focus on applications, the primary audience for this information is coastal modelers who generate and use digital elevation models (DEMs). A secondary audience is federal, state, regional, and local officials who may need to contract a data collection. This data inventory will help decision makers understand the current state of resources in their areas of interest and decide where best to invest their resources. In addition, the *Gulf Inventory* is focused on the best available data sets for an area. In many cases, high-resolution data with a precise vertical accuracy are publicly available, and only publically available data sets are included in this inventory, though some are available for purchase. This collection represents the state of topographic and bathymetric data as of November 15, 2007. At this time, there is no plan to keep this inventory updated. Inventory activities will focus on the Southeast region next.

THE *GULF INVENTORY* MAPS

The *Gulf Inventory* has two maps for each extent, one showing the location and sensor used for collection and one showing the collection date for data sets. These are often two critical pieces of information when determining the current state of elevation data. The extents of maps were determined by placing a grid over the study area and choosing those extents that showed the coastal and nearshore data. The grid was designed so that each extent has the same scale (1: 250,000). The maps contain a variety of information on the left side that is intended to guide use of the map, including the legend, compass rose, scale bar, map scale, index map, and reference information.

The set of maps showing the location of data sets, *Topographic and Bathymetric Data Gap Analysis by Location (Location Map)*, indicates the actual footprint of the topographic collection, and it shows the highest-resolution data set available for the coastal county. The bathymetric collections shown are all the bathymetric collections publicly available and Web-hosted for download. The focus of this map is to show the highest-resolution data sets available and the

precise location of coverage for these data sets. The legend items for this map indicate the type of topographic or bathymetric data available for each area:

- "LIDAR Complete" indicates that lidar has been contracted, collected, processed, and released. These data sets are available to the public, though some entities charge to acquire the data set.
- "LIDAR in Progress" indicates that lidar has been contracted and collected but not completely processed or released. This category implies that completion of lidar will occur and the data set will be released.
- "Photogrammetry" indicates that stereo imagery was used to delineate elevation contours and the elevation information is complete.
- "National Elevation Dataset" (NED) is the U.S. Geological Survey's (USGS) raster elevation data developed by merging a variety of data sources. It is available everywhere in the U.S. at 30-meter resolution and exists at a higher resolution where better elevation data sets have been collected.
- "Not in Study Area" indicates that the county or region was not included in the study area.
- "Proposed Topo LIDAR" refers to topographic lidar that has been proposed and funded but not collected or processed.
- "Proposed Bathy LIDAR" refers to bathymetric lidar that has been proposed and funded but not collected or processed.
- "NOAA Hydrographic Data" indicates bathymetric surveys conducted by the NOAA Office of Coast Survey. Multiple bathymetric collection techniques have been used in hydrographic surveys, including lead line soundings, single-beam sonar, and multibeam sonar. This feature on the map shows, to the degree possible, the locations of the actual bathymetric soundings. The density of points within a survey or the coverage by multiple surveys determines the darkness of the feature on the map.
- "USACE Dredge Surveys" indicates the location of U.S. Army Corp of Engineers (USACE) dredge surveys. Since these occur on different timelines, depending on traffic and sediment change rates, this feature is designed to notify people that dredge surveys occur in these areas. These surveys can be obtained from your USACE district office.
- "USGS Bathymetry Surveys" indicates that the USGS conducted a survey that included bathymetric data and that the data are available on-line.

The set of maps showing the collection dates of data sets, *Topographic and Bathymetric Data Gap Analysis by Collection Date (Collection Date Map)*, focuses on high-resolution topographic data, since many older topographic data sets (USGS NED) can be composed of multiple data sets from different years. The topographic and bathymetric data sets whose collection dates are known are included in this set of maps. In addition, the survey number of each NOAA hydrographic survey is included on the map for easy reference to the exact data set. The legend items for the *Collection Date Map* include four categories: "High-res Elevation Collection Date," "Shoreline LIDAR Collection Date," "NOAA Hydrographic Data," and "Proposed LIDAR Bathymetry."

- "High-res Elevation Collection Date" refers to data sets that cover large areas, as opposed to data sets for narrow strips along the coast. Many of these collections are countywide data sets, but other boundaries (task area, etc.) are sometimes used for collections.

- "Shoreline Lidar Collection Date" refers to data sets that collect only narrow strips of topography or topography and bathymetry along the shoreline. Typically, the surveys that collect topography and bathymetry collect a 500-meter swath of topographic lidar and a 1,000-meter swath of bathymetric lidar. These collections will usually occur more often than the surveys for large areas.
- "NOAA Hydrographic Data" refers to the bathymetric surveys conducted by the NOAA Office of Coast Survey. Multiple bathymetric collection techniques have been used in hydrographic surveys, including lead line soundings, single-beam sonar, and multibeam sonar.
- "Proposed LIDAR" refers to topographic or bathymetric lidar that has been proposed and funded but not collected or processed.

MAP USAGE

Maps can be accessed using the Internet at *www.csc.noaa.gov/topobathy/*. The maps are designed to look at the existing coverage of high-quality data and highlight where gaps exist. High-resolution, high-accuracy elevation (topography and bathymetry) data sets are necessary for many applications.

One such application is storm-surge inundation prediction. The digital elevation surface used in a storm surge model is critical to the accuracy of the prediction and can impact prediction of where inundation will occur. Using the most up-to-date elevation information contributes to a better prediction and can avoid loss of life and property when used for management decisions. This inventory is designed to assist the technical user in updating DEMs that combine topography and bathymetry, or a topobathy surface. The first step in creating a DEM surface is locating the best available data sets for an area, and this inventory aims to serve as a time-stamped record of the best available data.

Additionally, the inventory can be used to avoid duplication of data collection. If a state or local government agency is interested in collecting new elevation data, the inventory can serve as a reference to understand what data resources already exist. Using the inventory, the agency can examine existing data sets to determine whether they meet the necessary standard, or if new data need to be collected. Also, if the purpose of the collection of the data set is to update the topobathy surface, this set of maps can help visualize locations where the greatest need for data collection exists. For topography, every surface has coverage by a data set, but the gap may be caused by the need for a higher-resolution data set than the one that is available. For bathymetry, almost every area is covered, to varying degrees of density, with a bathymetry survey. Areas where the map shows that no data exist (areas of white space) often have the navigational chart data produced from the data. The original data sets are not easily accessed in digital form.

INFORMATION SOURCES

Topography

USGS National Elevation Dataset (NED) data and descriptive information are available on-line through the following website: *http://ned.usgs.gov*. This data set covers the entire U.S., including Hawaii, Alaska, and the island territories. The projection is geographic with the units in meters,

and the resolution is generally 1 arc second or 30 meters. Some areas have incorporated data of a higher resolution, making the NED data better quality. This data set is a product of merging multiple data sets of various resolutions. The highest resolution data sets available are used in constructing the final data set, but often high-resolution elevation data sets are not available for all areas.

Many federal, state, county, and regional groups collect high-resolution data sets, such as lidar and photogrammetry. Statewide collections are often the product of partnerships between federal, state, and county government officials. Counties have collected their own high-resolution elevation data as they have found need for the data (surveying, stormwater management, etc.). In many instances, these data sets are resold by the county to recoup the cost of collection and processing. The Federal Emergency Management Agency (FEMA) is often a major contributor to the updating of elevation information for use in more accurate flood mapping. Also, the NOAA Coastal Services Center often works with state, regional, and local entities to update data sets. If a federal agency is involved in collection, the data will be available in the public domain.

A few collections in the Gulf of Mexico have been organized at the state level.

- **Louisiana Statewide lidar** is an effort that began collecting lidar in 2002. The state has systematically updated major portions of the state every year since and is approaching completion of a statewide data set. These data sets were collected in cooperation with FEMA and satisfy FEMA's specifications for floodplain mapping. They are available for download from *http://atlas.lsu.edu/lidar/*. Note: The dates in the *Collection Date Map* reflect the date of the statement of work, rather than the date of completion of the data set, since these dates were not readily available.
- **Texas** has begun collecting a **coastal lidar** data set that covers all immediate coastal counties except three, one of which had already collected lidar. The funding for this collection is from FEMA in the wake of the impact Hurricanes Katrina and Rita had on the Texas coastal region. This collection is being coordinated through the Texas Water Development Board; data sets will be distributed through the Texas Natural Resources Information System's data download website (*www.tnris.state.tx.us/datadownload/download.jsp*) and will be distributed through the USGS Center for LIDAR Information Coordination and Knowledge (CLICK) website (*http://lidar.cr.usgs.gov*). Lidar has been collected, processed, checked for quality, and accepted, but the distribution mechanism for this collection is not yet functioning. Lidar can be requested from TNRIS while details are being finalized.
- **Florida** is in the process of contracting the collection of lidar for the coastal areas of Florida up to the current Category 5 surge zone delineation. In addition, Florida is collecting bathymetric lidar for select critical areas. This collection is funded, but data collection, processing, and quality assurance have not yet begun. This data collection is shown on the maps as an overlay of colored dots to indicate the collection in progress. Coordination of this collection is being done by the Florida Division of Emergency Management and a contract company they hired to assist in the effort, Jones Edmunds. There is no current plan for distribution of these data sets, but officials intend to distribute them when collection and quality assurance is complete.

Regional

- The **Northwest Florida Water Management District (NWFWMD)** has worked with the NOAA Coastal Services Center and individual counties to collect lidar in the panhandle of Florida. Through this partnership, updated elevation data have been collected for Santa Rosa, Escambia, and Walton Counties. In addition, substantial portions of Okaloosa, Bay, and Jefferson are being collected to complement the Florida DEM collection. These data sets are available through the NOAA Coastal Services Center's lidar download mechanism, LDART, at *www.csc.noaa.gov/ldart/*.
- The **Southwest Florida Water Management District (SWFWMD)** has been very proactive in collecting lidar to a high specification: 9-centimeter root mean square error. These collections are contracted to a high standard so that the data set can be used for a large variety of applications requiring different accuracies. All these collections are located on the western coast of Florida, covering part of the SWFWMD. Some collections are hosted through the USGS CLICK website (*lidar.cr.usgs.gov*), and the data will be hosted on the NOAA Coastal Services Center's lidar download mechanism, LDART, in early 2008 (*www.csc.noaa.gov/ldart/*).

Many individual counties in the Gulf region have collected their own lidar or other high-resolution elevation data sets.

- **Harris County, TX,** collected lidar countywide in 2001 through the Tropical Storm Allison Recovery Project. The 2-foot contours and the 15-foot DEM are available through the Harris County Flood Control District (*www.hcfcd.org/index.asp*).
- **Fort Bend County, TX,** contracted the collection of lidar to meet FEMA specifications (18-centimeter root mean square error) in 2005. The survey included 1-foot resolution digital photography, breaklines, and 2-foot contours. This data set is available through the Fort Bend GIS coordinator (*www.co.fort-bend.tx.us*).
- **Wharton County, TX,** was collected in 2006 at the same time as the Texas coastal lidar collection mentioned above. The Lower Colorado River Authority collected elevation data for the county that were a combination of photogrammetry and lidar. This data set is available for purchase from the county.
- Coastal **Mississippi** lidar for **Jackson, Harrison, and Hancock Counties** was collected in 2005 as a cooperative effort of the State of Mississippi and the NOAA Coastal Services Center. These data sets were collected to a specification more stringent than the FEMA specifications (15-centimeter root mean square error) and are available for download from the NOAA Coastal Services Center's lidar download mechanism, LDART (*www.csc.noaa.gov/ldart/*).
- **Mobile County, AL,** collected lidar in 2002, and it is available to the public. Data requests must be in writing and include language that indicates that the receiving party will not sell the data. Contact the Mobile County Engineering Department to request the data (251-574-8595).
- **Baldwin, AL,** collected lidar in 2005. This data set is available to most federal, state, county, and local governments free of charge. Other interested entities can purchase the data for $280 per township, and there are 65 townships in the data set. For additional information about this data set, contact the Baldwin County GIS coordinator (*www.co.baldwin.al.us*).

- **Okaloosa County, FL,** collected stereophotography, or photogrammetry, another form of high-resolution elevation data for the whole county in 2004. Collection of lidar for the coastal area of Okaloosa County is planned, and the remainder of the county is in the process of collection through the NWFWMD and NOAA Coastal Services Center (2007).
- **Leon County, FL,** collected lidar in 2002 and conducted updates in 2005 and 2006 for portions of the county. This data set is available from the Tallahassee-Leon County GIS Department.
- **Collier County, FL,** collected lidar in 2005, and this data set is available from the Collier County Mapping Department.

Shoreline collections

- **ALACE data are** a collection of topographic lidar from the land–water interface to 500 meters inland. These data sets were collected as part of a partnership between NOAA, USGS, and NASA. The shoreline lidar collected from these missions (1996-2000) is available on the NOAA Coastal Services Center's website (*www.csc.noaa.gov/ldart/*).
- Topographic lidar, and more recently topographic and bathymetric lidar, are collected along the shoreline by the **USACE**. These surveys typically collect information for 500 meters inland and 1,000 meters out to sea or to the extinction of the laser. The USACE has covered almost the entire U.S. shoreline where sandy beaches occur and hopes to establish a five-year cycle of beach monitoring by collecting topobathy lidar data. All USACE surveys are available on the NOAA Coastal Services Center's website at *www.csc.noaa.gov/ldart/*.

Other collections

- One lidar collection included in the inventory was conducted in response to an event, Hurricane Katrina. This collection surveys all of the Mississippi coast and part of the Alabama coast. This survey is available on the NOAA Coastal Services Center's website at *www.csc.noaa.gov/ldart/*.

Bathymetry

The sources for depth-accurate bathymetry are much more consolidated than for topographic surveys. These surveys are usually undertaken by NOAA for navigation, USACE for dredge projects, and USGS for geological studies. Each of these agencies collects bathymetry as part of its responsibilities mandated by Congress. Part of the reason these federal agencies take the lead in producing bathymetric depths is the relatively high expense of collecting accurate bathymetry, when accounting for boat time, equipment, and trained personnel. Also, this ensures that surveys are consistent with a certain standard.

- **NOAA bathymetric surveys** are conducted by the National Ocean Service Office of Coast Survey. Navigable waters are surveyed to specifications that meet International Hydrographic Organization (IHO) Order 1, which ensures that navigational obstacles are determined and charted. The bathymetric surveys use a combination of technologies, including lead line soundings, single-beam sonar, and multibeam sonar. Areas of open, navigable water that do not register as having bathymetric data (white areas where water exists) are instances where the data are not easily available in digital form. Navigation charts are produced for these areas, but the original data sets they are based on are not

currently served in digital form. In some areas, the hydrographic survey is denser than others. This is caused by using different technologies for collection and because of instances of multiple, overlapping data collections. On the *Location Map,* the actual locations of soundings are portrayed, which gives an idea of density of data points and which accounts for variation in the pattern representing "NOAA Hydrography." On the *Collection Date Map*, the survey number of the hydrographic survey is displayed so that the correct surveys can be downloaded. All NOAA bathymetric surveys used for charting can be found on the GEODAS website (*www.ngdc.noaa.gov/mgg/geodas/geodas.html*).

- Two types of **USACE** collections are shown in the inventory. The **lidar bathymetry** surveys have been mentioned previously as part of the shoreline lidar surveys. This is a collection of airborne lidar bathymetry and is served up on the NOAA Coastal Services Center's website at *www.csc.noaa.gov/ldart/*. The second type of bathymetry shown on the inventory maps are the **dredge surveys**. These surveys are conducted by the district offices, and the surveys vary based on need. Each program manager conducts these surveys with different frequency based on amount of use and sediment dynamics, and often a variety of equipment is used to collect data. Because of the variability in date or frequency of survey, these data sets are not included in the *Collection Date Map*. These data sets are available from the USACE district office responsible for maintaining the particular channel whose data are of interest. The areas where surveys should exist are marked on the maps as USACE maintained areas.
- In addition to hosting elevation data for the entire country, **USGS** also conducts **bathymetric surveys**. The surveys portrayed on the inventory maps are accessible from the Seafloor Mapping Program (*walrus.wr.usgs.gov/pacmaps/*) and Infobank (*http://walrus.wr.usgs.gov/infobank/*). USGS has lidar surveys and other sonar-based bathymetric data, but there is currently no central repository for data storage or access. The USGS bathymetric data sets were not included in the *Collection Date Map* because most of the surveys were not strictly vertically controlled and were out of this inventory's area of interest.

For additional information on the *Gulf Inventory* and these data sets, please contact the NOAA Coastal Services Center's Coastal Remote Sensing Program.